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## A BRASILIAN MODEL FOR NO-TILLAGE COTTON PRODUCTION ADAPTED TO THE SOUTHEASTERN USA

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Historical agricultural mismanagement of the soils in the southeastern USA has resulted in soil degradation, with consequent negative environmental and economic impacts. The climate in the region is humid subtropical and soils (mainly Ultisols) are heavily weathered. The use of conventional tillage, lack of crop rotation (especially monoculture of cotton (*Gossypium hirsutum* L.), burning or incorporation of crop residues, and cultivation of sloping and marginal lands has resulted in soil erosion and the loss of organic matter. Government programs have made great progress in addressing the problem of soil erosion, but until recently, the "hidden" problem of soil organic matter loss and resultant reduction in soil productivity has not been the focus of government and educational programs. In times of low commodity prices and reduced economic growth, farmers are reluctant to allocate labor, time, thought, or money to solve a problem unless it produces an immediate economic benefit.

Until very recently, cotton producers in the United States lagged behind corn (*Zea mays* L.) and soybean [*Glycine max* (L.) Merr.] producers in adoption of conservation tillage. As with these crops, inadequate management and fewer weed control options played a role in slowing adoption of conservation tilled cotton. Special considerations for cotton also reduced the adoption rate. Achieving adequate cotton emergence and plant populations in conservation tillage systems can be a problem due to: 1) cooler and wetter soil conditions in conservation tillage compared to conventional tillage, 2) cotton sensitivity to seedling diseases like *Rhizoctonia*, *Pythium*, and *Fusarium*, 3) sensitivity of cotton seedlings to allelopathic activity associated with cover crops, 4) poor seed-to-soil contact caused by planting equipment problems, and 5) soil compaction and crusting in degraded soils with low organic matter. Additionally, research has shown that conservation tillage can delay maturity and harvesting; a critical consideration in the more northern areas of the Cotton Belt (north Alabama, Tennessee, Virginia, and northern Texas) with a short growing season, and along the southern Gulf Coast (Alabama, Louisiana, Florida, and Mississippi), where delayed harvesting increases risks of crop loss from tropical storms and hurricanes.

When cotton producers initially tried conservation tillage some years ago, they simply eliminated their normal tillage operations, i.e., moldboard plowing or chisel plowing, followed by disking and seedbed leveling prior to planting. They did not use cover crops or crop rotations. In one of three years, this region undergoes a yield-limiting drought. Consequently, yields were reduced 5 to 15% compared to the prior-used conventional tillage system. The yield reduction was generally caused by soil compaction in the degraded, low organic matter soils (0.5 to 1.5 % organic matter); which reduced root growth, decreased infiltration, and increased risks from short-term droughts.

Brazil is a leader in adoption of conservation practices like no-tillage. The secret for this success in Brazil and neighboring countries like Argentina and Paraguay has been outlined by Derpsch (2001). Psychological and sociological reasons aside, a key technological difference between Brazil and its neighbors vs. the United States is an understanding that conservation tillage is a *SYSTEM* and not a single practice. Components of this system include the use of green manure cover crops, crop

rotation, integrated biological control of pests and weeds, and site-specific solutions to problems (Derpsch, 2001).

Beginning in 1990, researchers, extension specialists and farmers from Alabama and Georgia visited Brazil and Paraguay to see first hand conservation system development and adoption. We adapted the lessons learned from these countries to our soils and crops, especially cotton, which is the major cash crop in the southeastern USA. We focused on ameliorating two main problems in this subtropical region: 1) improving soil quality and reducing risks from short-term drought through the use of cover crops and crop rotation with a high-residue producing crop, and 2) management of soil compaction.

For upland silty-clay soils, a cereal cover crop, typically rye (*Secale cereale* L.) or wheat (*Triticum aestivum* L.) is used. Immediately prior to or following planting of the cover crop, some form of non-inversion tillage is performed under-the-row tillage in fall to reduce soil compaction. This can be accomplished with narrow-shanked parabolic subsoilers or bent-leg subsoilers like the Paratill<sup>7</sup> (Bigham Brothers, Inc., Lubbock, TX, USA) in such a manner as to have minimal surface soil and crop residue disturbance. The residual effect of the fall tillage carries over to the following cotton growing season. The combination of the use of a cover crop with the narrow-zoned non-inversion tillage reduces compaction; increases infiltration, increases yields, and increases soil organic matter (Motta et al., 2001). For these heavier soils, increases in soil carbon and consequent improvements in soil quality with time should reduce the need for the non-inversion tillage.

Ultisols of the USA Southeastern Coastal Plain are sandy, with low water-holding capacity, and typically possess root-restricting hardpans. Coastal Plain soils typically allow greater diversity in choice of cropping systems due to a longer growing season. Peanut (*Arachis hypogaea* L.) is often grown in rotation with cotton or corn. Winter grazing of stocker cattle on ryegrass (*Lolium multiflorum* Lam.), wheat, rye, or oat (*Avena sativa* L.) can be followed by a summer cash crop of cotton or peanut. However, research has shown that even long-term no-tillage cannot overcome yield limitations resulting from root-restricting hardpans inherent on these soils, and that some form of tillage is required to break through these layers (Reeves and Mullins, 1995). Consequently, the conservation tillage system of choice on these soils is termed *strip-tillage*.

Again, borrowing ideas from the Brazilian model, we modified their system to enhance water holding capacity, weed control, and productivity for these highly compactable soils. A cover crop of rye, wheat, oat or black oat (*Avena strigosa* Schreb.) is grown and terminated with a combination of a roller knife (rolo-faca) and glyphosate or paraquat. Black oat was introduced to the region through cooperative research efforts with IAPAR in Londrina, Paraná, Brazil. Residue amounts from the cover crops are 4.5 t/ha or greater. In-row subsoiling is then done in the same direction as the roller knife using a narrow-shanked subsoiler with pneumatic tires to close the subsoil slot with minimal surface soil and residue disturbance. Alternatively, we use a Paratill<sup>7</sup> equipped with a roller to disrupt the tillage pan and roll the cover in one operation. The cash crop, usually cotton or peanut, is planted into the rolled cover crop mulch four weeks after rolling. The four-week delay from termination to planting increases the probability of rainfall to recharge the soil profile for the cash crop, and reduces allelopathic effects on sensitive cotton seedlings. Using this system, in a three-year study, the increase in cotton lint yield compared to the traditional tillage system without a cover crop was worth an additional US\$548/ha/year. The yield increases were immediate and due to improved water conservation on these drought-prone soils.

We also modified planting equipment by adding residue managers (row cleaners) and spoked seed closing wheels. The row cleaners remove heavy accumulations of residue over the seed row, reducing hair-pinning of residue. This increases seed-to-soil contact, facilitates proper seed depth placement, and helps to warm the soil over the row, which is essential for cotton. Silty-clay soils are readily compacted at the seed placement zone (side-wall compaction) by solid seed closure wheels. The spoked closures firm the soil over the seed without causing side-wall compaction. Recently, the use of Real-Time Kinematic Global Positioning System (RTK-GPS) guidance systems allows equipment to plant directly over subsoiled zones that remain hidden by large amounts of residue in these systems.

These practices have played a key role in the dramatic increase of conservation tillage adoption in the southeastern USA. Estimates for adoption rates vary by source and state and even county. According to 2002 statistics from the Conservation Technology Information Center (CTIC, 2002), no-tillage cotton is grown on approximately 20% of the 5 million ha of cotton in the southern USA (which includes the Mid-South or Mississippi Delta). In some regions, I believe this estimate substantially under-estimates the adoption rate. A survey released in 2003 by the National Cotton Council of America reported that 57% of the total cotton acres in the southeastern USA were in no-tillage. My personal experience in Alabama leads me to believe that CTIC estimates are low. They report that 42% of the 245 thousand ha of cotton in Alabama is under no-tillage. Extension surveys and USDA-NRCS estimates put the figure somewhere between 68 to 75%.

Aggressive technology transfer through a partnering effort with university, federal, and private agribusiness also was a lesson learned and applied from the Brazilian model. The introduction of glyphosate resistant transgenic cotton in 1997 also facilitated the adoption increase, but in addition to the availability of the transgenic varieties, the partnering of companies like Monsanto with producers and government specialists to educate producers about the benefits of conservation tillage, and the practical methodologies needed for successful adoption was responsible for increasing the adoption rate. Often overlooked as a reason for adoption is the role of depressed economics of production. "*Crisis is the Mother of Change*", and the depressed cotton prices and droughts in the southeastern USA during the last four years have driven many farmers to use conservation tillage as a means to reduce input costs.

Although we have made great progress in adapting the Brazilian model for conservation systems to cotton production in the southeastern USA, there is still a lot we can learn from Brazil and other South American countries. The USA is still behind Brazil and other South American leaders in conservation tillage regarding the use of crop rotations and cover crops. Another emerging but key area that USA researchers and farmers can benefit from South American experiences with is the integration of livestock and forage rotations with conservation tilled row crops to increase soil carbon, improve soil quality, and reduce economic risks.

As agriculture moves rapidly to site-specific management, we do well to remember that no one solution solves every problem. However, the Brazilian model adapted to southeastern USA soils and crops, especially cotton, has played no small role in helping to sustain both our soils and our farmers.

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